



National Institute for Occupational Safety and Health
National Personal Protective Technology Laboratory
P.O. Box 18070
Pittsburgh, PA 15236

Procedure No. TEB-APR-STP-0033B	Revision: 2.2	Date: 08 August 2007
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DETERMINATION OF AMMONIA SERVICE LIFE TEST,
AIR-PURIFYING RESPIRATORS WITH CANISTERS
STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This test establishes the procedure for ensuring that the level of protection provided by air-purifying respirators with canisters (gas masks) submitted for Approval, Extension of Approval, or examined during Certified Product Audits, meet the minimum ammonia service life test requirements set forth in 42 CFR Part 84, Subpart I, Section 84.126.

2. GENERAL

This STP describes the Determination of Ammonia Service Life Test, Air-Purifying Respirators with canisters test in sufficient detail that a person knowledgeable in the appropriate technical field can select equipment with the necessary resolution, conduct the test, and determine whether or not the product passes the test.

3. EQUIPMENT / MATERIAL / REFERENCES

3.1. The list of necessary test equipment and materials follows:

- 3.1.1. Miller Nelson Research Model 401 Flow-Temperature-Humidity Control System (250 lpm) or equivalent. Air flow control accuracy is $\pm 2\%$ F.S. Temperature control accuracy is $\pm 1^\circ$ C. Humidity control accuracy is $\pm 3\%$ R.H.
- 3.1.2. Edge Tech Dew Prime II Hygrometer, Model 2000 or equivalent. Accuracy is $\pm 0.2^\circ$ C, $\pm 0.5\%$ RH.
- 3.1.3. Radiometer America Multi-Titration System, Model DTS 800, burettes or equivalent.
- 3.1.4. Air-Sentry IMS Ammonia Analyzer Model 10R-NH3-4000M or equivalent. Range for ammonia is 0.1 to 50 ppmv $\pm 0.1\%$ of full scale.
- 3.1.5. "The Gilibrator", Primary Standard Airflow Calibrator or equivalent.
- 3.1.6. Mass Flow Controllers, Brooks Instruments, variable flow rate depending on use, model series 5850S and 5853S. Accuracy is 0.7% setpoint & 0.2% FS.

Approvals:	<u>1st</u> Level	<u>2nd</u> Level	<u>3rd</u> Level
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- 3.1.7 Read Out and Control Electronics, Brooks Instruments, Model 0154.
- 3.1.8 Gilian Gil-Air-3 Sampling Pump, or equivalent.
- 3.1.9 Fisher Scientific Gas washing bottle or bubbler, catalog # 03-036 or equivalent.
- 3.1.10 American Meter Co. Dry Test Meter Model DTM-325.
- 3.1.11 Erlenmeyer flasks or beakers, 250 to 500 milliliters (mL).
- 3.1.12 Certified cylinder of approximately 50 ppmv ammonia in nitrogen.
- 3.1.13 Pipettes, 5 ml.
- 3.1.14 Boric Acid (granular).
- 3.1.15 Bromophenol Blue (powder).
- 3.1.16 Sulfuric Acid (concentrated) or certified 0.025N sulfuric acid solution.
- 3.1.17 Electronic balance with accuracy of 0.001 grams (g).
- 3.1.18 Ammonia cylinder, 99% purity.
- 3.2. Test fixture for mounting canisters. The test fixture used is specific to each manufacturer depending on how the canister is mounted to the facepiece. In most cases chin-style canisters use the 40 mm thread for which we have adapters. In cases where other thread sizes are used, the adapters of the respirator are affixed by hot melt glue to a PVC pipe tee of appropriate size. Front or back mounted canisters are tested with their breathing tubes and adapters.
- 3.3. The test chamber consisting of an approximately 12" x 12" x 7" air tight box, with 2 clamp type locks on the door opening lined with gasket material, and appropriate inlet, outlet and sampling ports. This fixture is not commercially available.
- 3.4 Refer to the following Work Instructions for further information on performing this test:
 - TEB-RCT-APR-WI-1001 – Laboratory Safety Procedures for Ammonia Tests
 - TEB-RCT-APR-WI-1101 – Calibration Procedures for Ammonia Tests
 - TEB-RCT-APR-WI-1201 – Start-Up and Shut-Down Procedures for Ammonia Tests
 - TEB-RCT-APR-WI-1301 – Using the LabView System for Ammonia Tests
 - TEB-RCT-APR-WI-1401 – Reporting Results for Ammonia Tests

4. TESTING REQUIREMENTS AND CONDITIONS

- 4.1. Prior to beginning any testing, all measuring equipment to be used must have been calibrated in accordance with the testing laboratory's calibration procedure and schedule. All measuring equipment utilized for this testing must have been calibrated using a method traceable to the National Institute of Standards and Technology (NIST) when available.
- 4.2. Any laboratory using this procedure to supply certification test data to NIOSH will be subject to the provisions of the NIOSH Supplier Qualification Program (SQP). This program is based on the tenets of *ISO/IEC 17025, the NIOSH Manual of Analytical Methods* and other NIOSH guidelines. An initial complete quality system audit and follow on audits are requirements of the program. Additional details of the Program and its requirements can be obtained directly from the Institute.*
***Note** 4.2 does not apply to Pretest data from applicants as required under 42 CFR 84.64.
- 4.3. Precision and accuracy (P&A) must be determined for each instrument in accordance with laboratory procedures and NIOSH/NPPTL guidance. Sound practice requires, under *NIOSH Manual of Analytical Methods*, demonstrating a tolerance range of expected data performance of a plus or minus 25% of a 95% confidence interval of the stated standard requirement. NIOSH/NPPTL P&A tolerance can be higher but not lower.
- 4.4. The precision and accuracy of this method was determined by validation testing of a single lot of commercially available multi-gas type cartridges. The results of these tests are shown in the table below.

TEST TYPE	MEAN SERVICE LIFE (MINUTES)	STD. DEV.
AS RECEIVED	39.15	3.64
EQUIL. 25% RH	103.92	8.72
EQUIL. 85% RH	118.25	10.0

- 4.5. Normal laboratory safety practices must be observed. Please refer to Material Safety Data Sheets and the current NIOSH Pittsburgh Health and Safety Program for the proper protection and care in handling, storing, and disposing of the chemicals and gases used in this procedure.
- 4.6. The cylinder of 99% ammonia, as well as the calibration gas cylinders, are typically used inside the laboratory fume hood. If there is a release of 99% ammonia outside the hood, sound an alarm, and any personnel in the laboratory should immediately exit from the building.

4.7 AMMONIA BENCH TEST FOR CANISTERS

4.7.1. Resistance to air flow of the complete respirator will be taken before and after each test (see 42 CFR 84.203). The standard testing procedures are described in TEB-APR-STP-003 and TEB-APR-STP-007.

4.7.2 Test conditions as required by 42 CFR 84.126.

SAMPLE	CONDITION	EQUILIBRATION CONDITIONS			TEST CONDITIONS			TEST CONCENTRATION		BREAKTHROUGH CONCENTRATION
		FOR 6 HOURS						FRONT AND BACK MOUNTED	CHIN STYLE AND ESCAPE	
		TEMP. °C	AIRFLOW LPM	R.H. %	TEMP. °C	AIRFLOW LPM	R.H. %	PPMV AMMONIA	PPMV AMMONIA	PPMV AMMONIA
1-3	AS RECEIVED	NA	NA	NA	25	64	50	30000	5000	50
4-5	EQUIL. 25% R.H.	25	64	25	25	32	50	30000	5000	50
6-7	EQUIL. 85% R.H.	25	64	85	25	32	50	30000	5000	50

Tolerances:

PARAMETER	TOLERANCE
25°C	± 2.5°C
25 LPM	± 0.25 LPM
32 LPM	± 0.50 LPM
64 LPM	± 1.0 LPM
25% R.H.	± 3% R.H.
50% R.H.	± 3% R.H.
85% R.H.	+0/-5% R.H.
5000 ppmv	± 10%
30000 ppmv	± 10%

NOTES: R.H. levels greater than 85% are difficult to maintain and may cause rapid degradation of service life.

Tolerance on accuracy of air flow rates exceeds specification on Miller Nelson control unit because flow rates are calibrated for every test. This improves the precision of the measurement and allows for the tighter tolerance on short-term drift.

4.7.3 All equilibrated canisters will be resealed, kept in a position such that the direction of airflow would be horizontal, at room temperature, and testing shall begin within 18 hours.

5. PROCEDURE

Note: Reference Section 3 for equipment, model numbers and manufacturers.
 Work Instructions are to be used in conjunction with standard NIOSH test apparatus.

- 5.1 Set up the test equipment as shown in Figure 1.
- 5.2 Calibrate the breakthrough NH₃ analyzer using the certified gas cylinder containing the 50 ppmv standard.

5.3 Prepare solutions:

- 5.3.1 5% boric acid: Heat, but do not boil, 50g boric acid in 1 liter distilled water.
- 5.3.2 0.025N sulfuric acid solution: Weigh 1.28g concentrated sulfuric acid and add to a 1 liter flask containing 800 ml distilled water. Dilute to 1 liter mark with distilled water.
- 5.3.3 Bromophenol blue solution: Dissolve 0.5g bromophenol powder in 500 ml distilled water. Shelf life of this solution is one month.

5.4 Prepare comparison blank:

- 5.4.1 Measure 50 ml boric acid solution (100 ml for 30,000 ppmv) into 250 ml Erlenmeyer flask. Add 25 ml distilled water, 5 drops bromophenol blue indicator, and distilled water equal to the calculated volume of sulfuric acid needed to determine NH₃ concentration.
- 5.4.2 Example: for a comparison blank equal to 5000 ppmv.

$$\text{Calculated vol. H}_2\text{SO}_4 = \frac{\text{ppmv NH}_3}{\text{standard factor}}$$

Where the standard factor = 611 ppmv NH₃/ml H₂SO₄

$$\text{vol. H}_2\text{SO}_4 = \frac{5000}{611}$$

$$\text{vol. H}_2\text{SO}_4 = 8.2 \text{ ml}$$

Total volume of water added including the 25 ml from step 5.4.1.
 = 33.2 ml.

- 5.5 Establish the correct humidity and temperature for the sample being tested as per the test requirements in paragraph 4.7.

- 5.6 Set the airflow to the required level for the sample being tested as per the test requirements in paragraph 4.7 and the adjustments in paragraph 5.12. Calibrate the total airflow, including any additional flow arising from hygrometer flow rates, from the test fixture using the dry test meter.
- 5.7 Weigh the canister(s) and record the weight.
- 5.8 Measure initial inhalation and exhalation resistances of the canister(s) mounted on the facepiece as described in TEB-APR-STP-003 and TEB-APR-STP-007. Record values on the data sheet.
- 5.9 Make sure diverter valve in the system is diverting the challenge concentration airflow to discharge and not into the testing chamber.
- 5.10 Mount canister(s) onto test fixture and place in testing chamber.
- 5.11 Open the 99% ammonia cylinder.
- 5.12 Establish the test concentration of 5,000 ppmv \pm 10% ammonia or 30,000 ppmv \pm 10% ammonia by setting the theoretical flow rate of pure ammonia to mix with the flow of air to produce the required concentration. For testing at 30,000 ppmv, the additional flow of 99% ammonia gas required is sufficient to require adjustment of the air flow rate to maintain the total flow rates within tolerances (see table below). Then, set the mass flowmeter to that level.

TOTAL FLOW RATE FOR TEST	5000 PPMV TEST		30,000 PPMV TEST	
	AMMONIA FLOW RATE	AIR FLOW RATE	AMMONIA FLOW RATE	AIR FLOW RATE
LPM	CC/MIN	LPM	CC/MIN	LPM
32	160	32	930	31.1
64	320	64	1860	62.1

- 5.13 Measure 50 ml boric acid solution (100 ml for 30,000 ppmv) into the gas bubbler. Attach Gil-Air 3 sampling pump to the intake side of the gas bubbler. Connect outlet side of bubbler to Gilibrator. Calibrate 1 lpm \pm 2% flow rate of the pump. This setting will be used to sample the ammonia upstream concentration.
- 5.14 Connect tubing from the sample side of gas bubbler into the Gil-Air pump and tubing from the inlet side of the gas bubbler into the upstream sampling port.
- 5.15 Turn Gil-Air pump on and sample at 1 lpm for 1 minute.
- 5.16 Remove gas bubbler, and transfer the solution into an Erlenmeyer flask.
- 5.17 Rinse the gas bubbler with 25 ml distilled water and transfer the washings into the flask.

- 5.18 Add 5 drops bromophenol blue indicator.
- 5.19 Titrate the sample with 0.025N H₂SO₄ until it matches the comparison blank color sample (see 5.3). Record ml used.
- 5.20 Calculate the concentration of NH₃ using the following formula:
Conc. in ppmv = ml H₂SO₄ used x standard factor of 611 ppmv NH₃/ ml H₂SO₄
Adjust the flowmeter setting as required. Once the ammonia concentration has been established and is stable, testing may begin. When approximately ½ of the required minimum service life has been reached, perform another titration to calculate the challenge concentration during the test.
- 5.21 Monitor and record challenge and breakthrough temperatures, challenge RH and breakthrough values and times throughout testing.
- 5.22 Run test until breakthrough of 50.0 ppmv is observed or minimum service life shown in section 6.2 is surpassed by 10%.
- 5.23 At end of test, system will automatically direct challenge concentration airflow through diverter valve to discharge.
- 5.24 Dismount canister(s), weigh and record final weight, and take final inhalation and exhalation resistances as described in TEB-APR-STP-003 and TEB-APR-STP-007. Measurement of the final inhalation and exhalation resistances is required for certification and audit testing.
- 5.25 If there is another sample to test, repeat steps 5.5 – 5.15.
- 5.26 After all tests are completed for the shift, set temperature and humidity to zero on the Miller Nelson system and allow clean air to pass through the system for 30 minutes. Purge the breakthrough and challenge detectors with clean air for 15 minutes.

6. PASS/FAIL CRITERIA

- 6.1. The legal basis for passing this test is set forth in 42 CFR Part 84, Subpart I, Section 84.126.

6.2 Minimum service life requirements for canisters are shown below.

Canister type	Test condition	Test atmosphere			Number of tests	Maximum allowable penetration (ppmv) ¹	Minimum service life (minutes) ²
		Gas or vapor	Concentration (ppmv)	Flow rate (liters per minute)			
Ammonia Front and Back Mounted	As received Equilibrated	NH ₃	30,000	64	3	50	6/12
		NH ₃	30,000	32	4	50	6/12
Ammonia Chin-Style	As received Equilibrated	NH ₃	5,000	64	3	50	6/12
		NH ₃	5,000	32	4	50	6/12
Ammonia Escape	As received Equilibrated	NH ₃	5,000	64	3	50	12
		NH ₃	5,000	32	4	50	12

¹Minimum life will be determined at the indicated penetration.

²For a combination respirator designed for respirator protection against one or more of the following types: ammonia, acid gas, organic vapor, or carbon monoxide, the minimum life shall be 12 minutes. For a combination respirator designed for respirator protection against all of the following types: ammonia, acid gas, organic vapor, or carbon monoxide, the minimum life shall be 6 minutes each for ammonia, acid gas and organic vapor. For escape gas masks the minimum life shall be 12 minutes.

7. RECORDS/TEST SHEETS

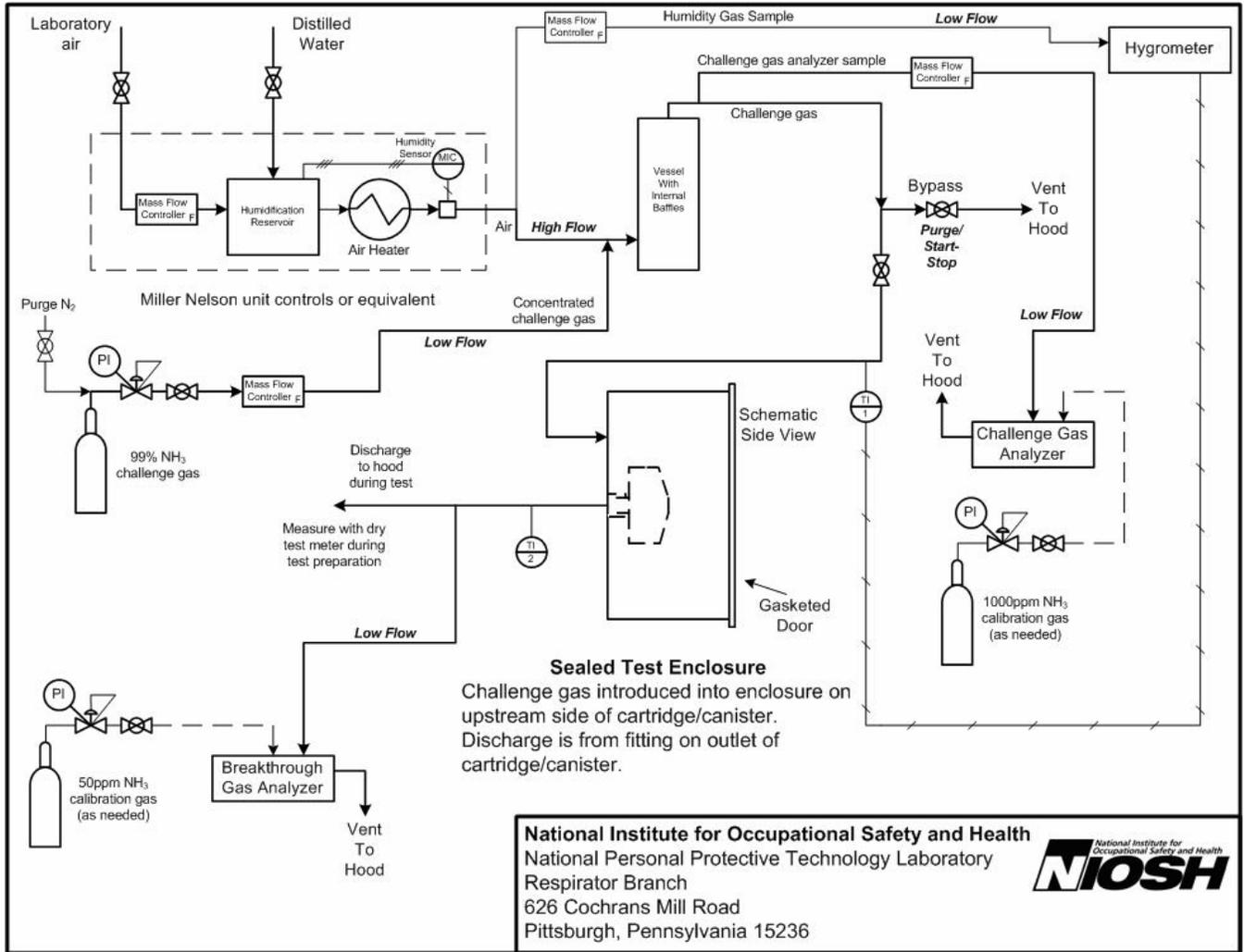
7.1. Record the test data in a format that shall be stored and retrievable.

8. ATTACHMENTS

8.1. Bench Top Set-up

8.2. Data Sheet

8.1 Bench Top Set-Up.



8.2 Data Sheet

 NIOSH <small>National Institute for Occupational Safety and Health</small> RB - RESPIRATOR CERTIFICATION TEAM	
GAS & VAPOR RESPIRATOR TEST DATA SHEET (Ref. 33-48,50,62)	
Task Number: TN-_____	STP No.: [_____]
Manufacturer: _____	Gas Name: _____
_____	Item Tested: _____

RESISTANCE	Maximum Allowable Resistance (mm of H ₂ O)				Actual Resistance (mm of H ₂ O)				Result
	Inhalation		Exhalation		Inhalation		Exhalation		
			Initial		Initial	Final	Initial	Final	
1									
2									
3									
4									
5									
6									
7									

Overall Results: Pass _____ Fail _____ Comment: _____

WEIGHTS AND AIRFLOWS	WEIGHTS (gm)				AIRFLOW (Lpm)			
	Con'd			Conc. (ppmv)	Test Rate		(PAPR Only)	
					RH%	Lpm	Initial	Final
1								
2								
3								
4								
5								
6								
7								

Overall Results: Pass _____ Fail _____ Comment: _____

DATA TABLE	Test Cond.	Final Time (min)	Leakage (ppmv)	Temperature (°C)		Corrected Time (min)
				Downstream	Upstream	
1						
2						
3						
4						
5						
6						
7						

Overall Results: Pass _____ Fail _____ Comment: _____

Was all testing equipment in calibration throughout all testing: Yes _____ No _____

Signature: _____ Date: _____

 <p>NIOSH National Institute for Occupational Safety and Health</p> <p>RB - RESPIRATOR CERTIFICATION TEAM GAS & VAPOR RESPIRATOR TEST DATA SHEET (Ref. 33-48,50,62)</p> <p>Task Number: TN- _____ Gas Name: _____ Manufacturer: _____ Item Tested: _____</p> <p>STP No.: [_____]</p>	Page 2
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Additional Comments: Signature: _____ Date: _____
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Revision History

Revision	Date	Reason for Revision	
1.0	March 8, 2002	Historic document	
1.1	June 6, 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method	
2.0	18 December 2006	Significant rewrite of RCT-APR-STP-0033. Changes affect form and provide clarification of technical content.	
2.1	25 July 2007	Correct tolerance for 85% humidity in table on page 4. Was +5/-0%	
2.2	8 August 2007	Section	Modification
		5.3.3	Added reference to solution shelf life
		5.4.1	Added solution volume (100 ml for 30,000 ppmv)
		5.4.2	Addressed significant digits for volume quantities
		5.5	Strike "and the adjustments in paragraph 5.12."
		5.6	Strike "challenge gas flow rates and / or"
		5.12	Add "For testing at 30,000 ppmv, the additional flow of 99% ammonia gas required is sufficient to require adjustment of the air flow rate to maintain the total flow rates within tolerances" Flow rate table replaced
		5.17	Correct volume to 25 ml, and strike "or the predetermined calculated volume depending upon the concentration desired (see 5.3)"
		6.2	Table: Ammonia Escape challenge concentrations and breakthrough times corrected from 30,000 to 5,000, and from 6/12 to 12, respectively.